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Digital finance and financial literacy: Evidence from Chinese households☆

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ABSTRACT

We measure financial literacy and study its impact on household use of digital finance using the 2015 and 2017 China Household Finance Survey. We find that financial literacy significantly boosts the use of digital finance, including mobile payments, online borrowing, and online financial products. This effect is more pronounced for online borrowing and online financial products than for mobile payments. This result suggests that the impact of financial literacy increases with the complexity of digital finance. Furthermore, financial literacy plays a more important role in promoting the use of digital financial services among disadvantaged groups, such as families with low income and wealth, the elderly, and residents in rural areas, compared with their counterparts.

1. Introduction

Digital finance has shown tremendous potential in reaching previously excluded and underserved populations by offering further tailored financial services and products. The existing literature showed that advancements in digital finance create new and affordable investment opportunities, leading to good welfare benefits and great financial inclusion (Cocco et al., 2005; Demir et al., 2020; Demirguc-Kunt et al., 2018; Shen et al., 2020). Furthermore, digital finance fortifies financial system resilience and bolsters financial stability by rivaling traditional finance businesses (Jack and Suri 2014; Buchak et al., 2018; Ozili 2018).

Yet, emerging financial innovations, such as mobile banking, online financial management products, peer-to-peer (P2P) lending, automated portfolio managers (robo-advisors), and advanced trading platforms, meld technology, regulation, user behavior, and global market dynamics. These developments contribute to the increasing complexity of digital finance, which requires households to have adequate financial literacy and knowledge. Moreover, the liberalization of financial markets among competing financial technology (fintech) companies has placed a significant responsibility on individuals to acquire financial knowledge. Financial knowledge allows individuals to make informed economic and financial choices, avoid financial errors or missteps, and ensure their financial well-being. A lack of financial knowledge[2] may lead to the exclusion of certain individuals from digital financial services and products, consequently depriving them of the relevant technological empowerment. This study aims to analyze the role of financial literacy in

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[2] Substantial evidence indicates the prevalence of financial illiteracy, with many individuals lacking even basic financial knowledge (Lusardi and Mitchell 2007; van Rooij et al. 2011). For example, in the 2016 OECD/INFE Survey of Adult Financial Literacy Competencies (OECD 2016) covering 30 countries and economies, including 17 OECD countries, only 56% of adults achieved the minimum target score for financial knowledge (five out of seven).

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explaining households' access decisions to digital finance.

Financial literacy—"a combination of awareness, knowledge, skill, attitude and behavior necessary to make sound financial decisions and ultimately achieve individual financial well-being" (Atkinson and Messy 2012)—is identified as a critical factor in diverse aspects of individual financial decision-making. Examples include opening bank accounts (Cole et al., 2011), investing in stocks (van Rooij et al. 2011), purchasing life insurance (Wang et al., 2021), planning for retirement (Lusardi and Mitchell 2017), accumulating wealth (Jappelli and Padula 2013), diversifying portfolios (Gaudecker 2015), and making good financial decisions (Disney and Gathergood 2013; Guisoand Viviano 2014).

Despite the burgeoning body of research accentuating financial literacy, its relationship with the uptake of digital finance remains underexamined. Predominantly, the extant studies mainly focused on the role that financial literacy plays in contexts such as Internet banking (Andreou and Anyfantaki, 2021). However, a gap in understanding the influence of financial literacy on household engagement with digital financial services of varying intricacy exists. Furthermore, the impact of this effect on different demographic, socio-economic, and geographic dimensions remains to be elucidated.

In this context, this study employs the China Household Finance Survey (CHFS), which interviews approximately 40,000 households across the country. The objectives of our study are to measure the use of different types of digital finance by Chinese households, estimate the financial literacy level of individuals with different demographic characteristics, and assess the extent to which changes in financial literacy affect the use of digital finance. The survey results reveal that the usage of digital finance is still low and mainly dominated by mobile payment. Overall, 29.1% of the households use digital finance, whereas the adoption of mobile payments, online financial products, and online borrowing among the respondents is 28.1%, 6.6%, and 4.4%, respectively. In addition, the level of financial knowledge proficiency, measured by the answers to three questions involving economic concepts of interest rates, inflation, and financial risk, among Chinese households is fairly low. Notably, the weighted percentages of respondents who did not understand and could not answer these three questions are 48.6% (interest rate), 45.9% (inflation), and 39.0% (financial risk). The level of financial literacy is significantly low among the elderly; male households with low levels of education, personal wealth, and income; and residents living in rural and economically underdeveloped areas.

The empirical analyses show that household financial literacy significantly enhances the use of digital finance. Other things being equal, for every one standard deviation increase in financial literacy, the probability of using digital finance increases by 2.87 percentage points. Notably, the impacts of financial literacy are more pronounced for online borrowing and online financial products than for mobile payments. This result indicates that the importance of financial literacy is amplified as the complexity of digital finance rises. We further implement the heterogeneous analyses and find that the effects of financial literacy significantly vary across different population groups. Specifically, financial literacy plays a more important role in encouraging the use of digital financial services among disadvantaged groups, such as families with low levels of wealth and income, the elderly, and rural residents, compared with their counterparts. Financial literacy is particularly important for them to overcome barriers to digital financial inclusion.

In the empirical analysis, we control for demographic, socio-economic, and geographic factors in the regressions. However, unobservable factors that affect the respondents' financial literacy and their use of digital finance simultaneously might still exist. Another potential concern is reverse causality. Households who are actively engaged in digital finance are likely to show a heightened interest in improving their financial knowledge, given their increased stake in the process. We employ several instrumental variables (IVs) to address potential endogeneity concerns, including the education levels of the respondents' parents, neighborhood financial literacy, and the respondents' social identities. The IV estimation results confirm the positive effect of financial literacy on the use of digital finance. Moreover, we employ various alternative measures of financial literacy to mitigate potential measurement errors. We account for cognitive abilities and peers' financial literacy to disentangle the impact of knowledge from innate talents and peer influences on individuals' decisions to use digital finance. We also rule out the potential influence of households that have voluntarily opted out of using digital finance.

Our study also explores the mechanisms through which financial knowledge facilitates the use of digital finance. Our findings suggest that financial literacy increases individuals' access to online financial information, helping them make informed decisions about using digital finance. In addition, households possessing high levels of financial literacy are likely to trust in new things and have a high tolerance for financial risks. Hence, they are receptive to digital finance.

This research contributes to the existing literature in several ways. We build on Andreou and Anyfantaki (2021), who focused on the role of financial literacy in Internet banking in Cyprus. We broaden this perspective by evaluating the influence of financial literacy on household adoption of various digital financial services, including mobile payments, online borrowing, and online financial products. The finding that the impacts of financial literacy increase with digital finance complexity has important policy implications. Given the growing complexities in fintech offerings, consumers should be urgently equipped with the requisite knowledge and competencies, to ensure optimal choices in various digital finance for enhanced financial well-being.

Our study distinguishes from the extant literature by exploring the mechanisms that underpin the relationship between financial knowledge and digital finance adoption. The role of financial literacy in affecting households' decision-making and improving their financial outcome has been recognized. However, knowledge of its working mechanism is still limited. Most studies in this area focused on establishing causality, with little effort devoted to investigating the pathways of the effects. We carefully unpack the channels through which financial literacy changes consumers' adoption of digital finance. In particular, we examine how financial literacy assists consumers in lowering the costs of obtaining information, improves their trust in digital technology, and increases their receptivity to financial risks. Understanding the mechanisms of consumer and societal acceptance of digital finance is critical not only to fill a gap in the academic literature but also to inform public policies on designing additional effective financial education initiatives in the digital age.

This study also sheds new light on the financial inclusion literature. Cole et al. (2011) show that financial literacy education in emerging market countries only increases the likelihood of opening a bank account for households with little education or financial literacy. Based on a representative survey of 143 countries, Grohmann et al. (2018) find that financial literacy has a positive impact on financial inclusion. We extend the literature by examining digital financial inclusion. Despite the promise of digital finance to provide affordable, accessible, and adaptable financial services, its usage remains low in many emerging economies, such as China. Our research shows that a lack of financial literacy significantly curtails digital finance adoption. Although digital finance serves as an essential instrument for advancing financial inclusion, households are required to cope with increasingly complex financial decisions.

2. Institutional background

Despite China's remarkable progress in financial inclusion, the country still has the world's largest unbanked population (Demirguc-Kunt et al., 2018). Approximately one-fifth of all adults (255 million) do not have an account with a formal financial institution, accounting for 13% of the world's unbanked population. Digital finance could synergistically complement traditional financial intermediaries, particularly by extending financial services to areas that are often

underserved or neglected by inefficient Chinese financial institutions (Demirguc-Kunt et al., 2018).

Over the past decade, digital finance has developed rapidly in China as an alternative finance model. This trajectory can be traced back to December 2004, with the introduction of Alipay, a mobile payment solution developed by the e-commerce platform—Taobao. Mobile payment rapidly gained popularity in China owing to its greater convenience (wider coverage without intermediaries), better features (easier to use and lower costs), and higher quality of service (faster and safer transactions) than other traditional modes of payment. Remarkably, each of the two leading mobile payment service providers in China, Alipay and WeChat Pay, now has approximately 900 million users.

In addition to mobile payment, FinTech Unicorns, such as Ant Finance, Tencent, Baidu, and JD Digits, offer a range of online financial products and services to their customers by utilizing digital technology and big data analysis (Huang 2020). For example, Ant Finance launched Yu'ebao in 2013. Yu'ebao enables Alipay customers to transfer money between their payment account and money market account and earn an interest rate on their residual funds, which is much higher than conventional bank deposit rates.

The investment opportunities offered by online financial products hold considerable advantages over traditional bank offerings. On the one hand, online financial products have significantly reduced the barriers that households face when investing in the financial market. For instance, one can invest in a money market fund with as low as one Chinese yuan. Online financial products are also appealing owing to their convenience. Consumers can invest seamlessly, anywhere and anytime by using their mobile devices without having to physically visit a bank branch. On the other hand, the inherently low overhead costs of digital platforms enable these online financial products to offer reduced fees and competitive interest rates. This cost-efficiency, in turn, provides investors with access to a variety of investment products, facilitating portfolio diversification and the potential for superior returns. Therefore, the customer response to the online financial products provided by FinTech Unicorns was astonishing. Within a mere six months post-launch, Yu'ebao garnered an impressive 43 million subscribers. In Q1 2017, Yu'ebao, with assets of CNY 1.1 trillion (USD 117 billion), overtook JP Morgan's US government money market fund and became the largest money market fund in the world (Chui 2021).

Recent advances in fintech have also facilitated the development of online borrowing as an alternative source of funding, particularly benefiting low-income households and small and medium-sized enterprises (SMEs). They often face challenges in accessing traditional bank credit owing to the lack of historical data, insufficient collateral, or absence of government guarantees. To bridge this gap, digital banks, such as WeBank, MyBank, and XWBank, have developed proprietary credit scoring models using big data analytics and innovative solutions (Gambacorta et al., 2019). Moreover, online consumer lending services provided by fintech giants, such as Ant Group's Huabei and Jiebei, have grown rapidly and become important drivers of consumer spending. Between June 2020 and June 2021, nearly 500 million users borrowed money from Huabei and Jiebei. In the first half of 2020, the revenue of these lending services reached RMB 28.3 billion, accounting for 39% of Ant Group's revenue before the introduction of new regulations at the end of 2020 (Yu and McMorrow 2021). Furthermore, in 2015, the Chinese witnessed a boom in P2P lending, enabling thousands of platforms and hundreds of billions of dollars in loans, easing financial constraints faced by small businesses and consumers. As one of the booming fintech industries, China's P2P online lending credit scale reached RMB 3.9 trillion in 2017, equivalent to USD 700 billion (Nemoto et al., 2019). However, years of unregulated expansion have given rise to numerous cases of fraud, ultimately leading to the closure of these platforms in the Chinese financial market.

3. Data, key variables, and summary statistics

3.1. Data

The data used in this research come from the 2015 and 2017 CHFS, which contain very detailed demographic and financial information at the household and individual levels, including assets, wealth, and income. The survey is designed to be representative of Chinese households, which uses a multi-stage stratified random sampling process with probability proportionate to size. The survey covered 83 cities in 29 provinces, municipalities, and autonomous regions, including a total of 37,340 households in 2015 and 40,011 households in 2017. We exclude observations in the 1% tails for the key variables, such as household wealth and income, householder age, and number of household members, to minimize the potential influence of outliers. To alleviate simultaneity bias, our dependent variable—the use of digital finance—comes from the 2017 wave of the survey, whereas our explanatory variables—including financial literacy—are from the 2015 wave. The final sample contains 19,788 observations.[3]

3.2. Measures of digital finance

The CHFS has several survey questions designed to measure whether respondents have used any form of digital finance, that is, mobile payments, online financial products, and online borrowing. Specifically, mobile payment refers to a payment made through portable electronic devices (tablets or mobile phones), such as Alipay (Alibaba), WeChat Pay (Tencent), and Apple Pay (Apple). Online financial products are Internet-based wealth management products, such as Yu'ebao (Alibaba), Licaitong (Tencent), JD Xiaojinku (JD.com), and Baifa (Baidu). Online borrowing includes online consumer finance (e.g., Huabei and JD IOU), loans provided by Internet banks (Webank, Mybank, etc.), online cash lending (Ali microfinance, Ant Borrow, etc.), and P2P lending.

Therefore, we construct three binary variables to reflect the use of these three types of digital financial services, namely, *Mobile_Payments, Online_FPs*, and *Online_Borrowing*. They take a value of 1 if the respondent has used the service and 0 if otherwise. We collectively denote the use of digital finance with a binary variable (*Digital_Finance*), which takes a value of 1 if the respondent has used any of these services and 0 if otherwise.

3.3. Measures of financial literacy

Financial literacy is a form of human capital that includes understanding financial concepts and knowledge needed to make important financial decisions. In our study, financial literacy refers specifically to financial knowledge as a form of human capital, rather than the broad term "financial capability," which includes financial knowledge, financial behavior, and financial self-efficacy (Lusardi and Mitchell 2014; Feng et al., 2019).

In the CHFS, similar to Lusardi and Mitchell (2011, 2014), Lusardi and de Bassa Scheresberg (2013), and Grohmann et al. (2018), three questions are asked to assess respondents' financial literacy. These three questions deal with the concept of interest rates and compound interest (*Quiz_Interest*), the effects of inflation (*Quiz_Inflation*), and the financial risk of stocks and bonds (*Quiz_Risk*). Three types of answers are recorded for each question: (1) the respondent understood the question and answered correctly (*Correct*); (2) the respondent understood the question but did not give the correct answer (*Incorrect*); (3) the respondent did not understand the question and could not answer (*Do_Not_Know*).

[3] The 2017 wave only interviewed approximately 1000 new respondents about financial literacy, and data on digital finance are only available from the 2017 wave.

Appendix A1 contains the exact wording of the three questions that measure financial literacy.

Table 1 reports the descriptive statistics for the responses to these three questions. We used sampling weights to ensure that our statistics are representative of the population. The weighted percentages of correct responses to the *Quiz_Interest, Quiz_Inflation*, and *Quiz_Risk* questions are 28.5%, 16.2%, and 51.4%, respectively.[4] However, the weighted percentages of respondents who did not understand and could not answer the question are 48.6% (*Quiz_Interest*), 45.9% (*Quiz_Inflation*), and 39.0% (*Quiz_Risk*). This result suggests that the respondents surveyed have limited financial/economic knowledge. The prevalence of financial illiteracy in China poses a significant obstacle to the use of digital finance in households.

We follow Lusardi and Mitchell (2008), van Rooij et al. (2011), and Feng et al. (2019) in constructing two dummy variables to differentiate between the "incorrect" and "do not know" answers. *Quiz_Correct* is equal to 1 if the respondent answered the question correctly and 0 if otherwise, and *Quiz_DK* is equal to 1 if the respondent chose the "do not know" answer and 0 if otherwise. We compute financial literacy scores for each respondent using the six indicators associated with these three financial literacy questions. Specifically, we identify the presence of a single factor using factor analysis as only one component exhibits eigenvalues greater than one. Next, we conduct an iterated principal factor analysis to compute our composite index of financial literacy (*Literacy_Index*). An advantage of factor analysis is that it considers the difference between "incorrect" and "do not know" answers but does not assume that a respondent who provided an "incorrect" answer had greater financial knowledge than one who responded "do not know." Appendix A2 and Table A2 give details of the factor analysis.

Alternatively, we use rating scales (*Literacy_Score1* and *Literacy_Score2*) to measure the degree of respondents' financial knowledge. *Literacy_Score1* is a variable with a three-point scale. Specifically, if the respondent answered the question correctly, then she/he receives 1 point and 0 if otherwise. With three financial literacy questions, the value of *Literacy_Score1* ranges from 0 to 3, with 0 representing the lowest level of financial literacy and 3 the highest. Likewise, *Literacy_Score2* is a variable with a six-point scale. Specifically, the respondent receives two points if she/he answered the question correctly (*Correct*); one point if she/he understood the question but gave an incorrect answer (*Incorrect*); and zero points if she/he did not understand the question (*Do_not_Know*). The value of *Literacy_Score2* therefore ranges from 0 to 6, with 0 reflecting the lowest level of financial literacy and 6 the highest.[5]

3.4. Demographic, socio-economic, and geographic factors

In addition to the financial literacy index, our empirical specification considers other determinants of household financial behavior, which have been widely recognized by previous studies (Haliassos and Bertaut 1995; van Rooij et al. 2011, 2012; Lusardi and Mitchell 2014; Gaudecker 2015). We control for demographic factors—age, gender, marital status, health status, and household size; socio-economic factors—financial situation, personal income, home ownership, occupation (employed/entrepreneur), and political status (communist party member); and geographic factors—rural or urban area, local economic and financial development, and Internet access. Specifically, we include the age of the household head (*Age*) and its square (Age^2) to control for lifecycle factors; education level (*Education*), marital status (*Married*), health status (*Unhealth_Ratio*), family size (*Size_Household*), and political status (*Party*) to reflect the individual's/household's background; and home ownership (*Homeowner*), employment status (*Employed* or *Entrepreneur*), total wealth (*Wealth*), and total disposable income (*Income*) to control for the household financial situation.

Furthermore, we control for householders' cognitive abilities by including two additional dummy variables, *Ability_High1* and *Ability_High2*. *Ability_High1* is equal to 1 if the respondent could answer the survey questions with little assistance from the interviewer and 0 if otherwise. Then, *Ability_High2* is equal to 1 if the respondent was overall able to understand the questions and 0 if otherwise. Respondents who could answer the questions by themselves and understand them easily should have high cognitive abilities. The perceived cognitive ability of the respondent is based on the subjective assessment of the respondent by the interviewer and the objective quality of the respondent's responses to the questions.

Last, we include a dummy variable for whether the household lives in a rural area (*Rural*), the number of bank branches in the community where the household resides (*No_Branches*), broadband access rates (*Broadband_Access*), and the gross regional product per capita (*GRP_PC*) in the city where the household resides. The objective is to control for the potential impacts of local economic and financial development on the use of digital finance. We also include province dummies to control for uneven development across different provinces. As shown in Table 2, the summary statistics for these variables are roughly in line with Song et al. (2020) and Wang et al. (2021). See Appendix B for detailed definitions of all the variables.

3.5. Stylized facts

Table 2 presents descriptive statistics for the key variables used in this research. On average, 29.1% of the households in our sample use digital finance. Among the respondents, 28.1% used mobile payments, 6.6% used online financial products, and 4.4% used online borrowing. The mean values of *Literacy_Index, Literacy_Score1* and *Literacy_Score2* are 0.014, 0.892, and 2.484, respectively, suggesting that, on average, households possess a very low level of financial knowledge.

We further examine differences in financial literacy across population groups. The descriptive statistics presented in Table 3 reveal significant gaps among regions. For example, on average, urban households have a financial literacy index (*Literacy_Index*) of 0.315, which is significantly higher than that of rural households (−0.364). These results are in line with those of Cui et al. (2019), who find that people living in urban areas have better financial capabilities than those in rural areas. The financial literacy of households in the economically well-developed eastern regions (0.065) is significantly higher than that of households in the western (0.043) and central (−0.062) regions with lower per capita income. Moreover, women are more financially literate than men, younger people more than mature people, and married people more than unmarried people. These results are different from the findings of Atkinson and Messy (2012), who report that overall female respondents have lower financial knowledge than male counterparts using a sample covering 13 countries across four continents. According to Lusardi and Mitchell (2007), financial literacy is notably deficient among young individuals. Additionally, Agarwal et al. (2009) find that younger and older adults make more financial errors than middle-aged adults. In China, older individuals tend to have lower levels of financial knowledge than younger counterparts probably because of their long experience of living in a centrally planned economy. Individuals who grow up with limited formal financial literacy education often find themselves compelled to acquire financial knowledge through their own

[4] Our data on the three financial literacy questions (*Quiz_Interest, Quiz_Inflation*, and *Quiz_Risk*) are consistent with Feng et al. (2019), who also used the 2015 wave of the CHFS data to analyze the impact of financial literacy on household debt and assets. They show that 30.2%, 17.6%, and 54.6% of respondents correctly answered questions about interest rates, inflation, and risk, respectively.

[5] The *Literacy_Score2* variable entails an assumption that a respondent who provides an "incorrect" answer has greater financial knowledge than the one who provides a "do not know" answer, which might not be entirely fair. Therefore, we only use *Literacy_Score2* in robustness tests as it may over-interpret "do not know" answers.

Table 1
Responses to the three questions about financial literacy.

	Quiz_Interest		Quiz_Inflation		Quiz_Risk	
	Number	Percentage	Number	Percentage	Number	Percentage
Correct	10,412	28.5%	5901	16.2%	17,911	51.4%
Incorrect	8358	22.9%	13,806	37.9%	3364	9.7%
Do_Not_Know	17,726	48.6%	16,728	45.9%	13,589	39.0%
Aggregate	36,496	100.0%	36,435	100.0%	34,864	100.0%

Notes: This table reports the number of respondents and the weighted percentage of households providing correct, incorrect and *Do_Not_Know* answers to each of the financial literacy questions. The data are from the 2015 CHFS. The three questions concern the following concepts: numeracy and capacity to perform calculations relating to interest rates such as compound interest (*Quiz_Interest*); understanding of inflation (*Quiz_Inflation*); and understanding of financial risk (*Quiz_Risk*). We use sampling weights to ensure that the statistics are representative of the population. Appendix B provides detailed definitions of all the variables.

Table 2
Summary statistics of the key variables.

		N	Mean	SD.	Min	Max
	Digital finance	19,788	0.2908	0.4542	0	1
Dependent Variables	Digital_Payment	19,788	0.2811	0.4495	0	1
	Online_FP	19,788	0.0661	0.2485	0	1
	Online_Borrowing	19,788	0.0437	0.2044	0	1
Independent Variables	Literacy_Index	19,788	0.0144	1.0704	−1.7631	1.4782
	Literacy_Score1	19,788	0.8928	0.8989	0	3
	Literacy_Score2	19,788	2.4838	1.9702	0	6
	Financial_Class	19,788	0.0565	0.2309	0	1
	Log(Wealth)	19,788	12.3487	1.6879	7.0246	16.2186
Control Variables	Log(Income)	19,788	10.5335	1.2956	6.2166	13.3897
	Age	19,788	53.9158	13.0647	25	87
	Age^2/100	19,788	30.7759	14.5627	6.2500	75.6900
	Male	19,788	0.8055	0.3958	0	1
	Single Female	19,788	0.0579	0.2336	0	1
	Married	19,788	0.8065	0.3950	0	1
	Education	19,788	8.8501	4.0116	0	22
	Size_Household	19,788	4.1512	1.8096	1	10
	Unhealthy_Ratio	19,788	0.1187	0.2237	0	1
	Employed	19,788	0.4401	0.4964	0	1
	Homeowner	19,788	0.8978	0.3029	0	1
	Entrepreneurship	19,788	0.1581	0.3648	0	1
	Party	19,788	0.1550	0.3619	0	1
	Ability_High1	19,788	0.5553	0.4969	0	1
	Ability_High2	19,788	0.5964	0.4906	0	1
	Rural	19,788	0.4431	0.4968	0	1
	No_Branches	19,788	1.0784	1.8184	0	25
	Broadband_Access	19,788	0.4199	0.2766	0.0428	1
	Log(GRP_PC)	19,788	10.6740	0.5389	9.5597	11.9150

Notes: This table reports summary statistics of the variables. We use sampling weights to ensure that the statistics are representative of the population. Detailed definitions of all the variables are provided in Appendix B.

life experiences. A correlation exists between education/wealth/income and the level of financial literacy. People with higher education, wealth, and income are likely to have higher financial literacy than those with lower levels of education, personal wealth, and income.

Table 4 compares the use of digital finance among various population groups. Similar to financial literacy, the use of digital finance also varies by region. Specifically, access to digital finance is more prevalent among households in the eastern regions, where 32.7% have access, compared with 24.2% in the central regions and 30.3% in the western regions. The disparity between rural and urban areas is remarkable. Of the urban residents, 42.4% have used digital financial services, whereas the proportion is only 12.4% among rural residents. Additionally, younger, married, and female householders are more likely to use digital finance than their older, unmarried, and male counterparts. The use of digital finance increases with wealth, income, and education levels. Importantly, the percentage of households using digital finance increases with the financial literacy index, suggesting that households with greater financial knowledge are more likely to use digital finance.

4. Financial literacy and digital finance

4.1. Baseline results

We first estimate the impact of financial literacy on the use of digital finance using a probit model. Table 5 reports the regression results with cluster-robust standard errors.[6]

Column 1 shows that financial literacy significantly increases the probability of using digital finance, with a marginal effect of 2.69%. Given that the standard deviation of the financial literacy index is 1.070, a one standard deviation increase in financial literacy is associated with a 2.87 percentage point (=2.69% × 1.070) increase in the probability of

[6] Although pooled probit models cannot consider unobserved heterogeneity, they provide consistent estimates of the relevant parameters. In our study, we employ clustered standard errors at the community level to ensure appropriate inference. The main advantages of pooled estimations are that exogenous regressors are not strictly necessary, and predetermined variables can be accommodated (Wooldridge 2010; Ding et al. 2021). As a result, pooled probit models can be more robust than random-effects probit models, which assume strict exogeneity.

Table 3
Financial literacy by demographics.

	Literacy_Index	Literacy_Score1	Literacy_Score2
Nation	0.0144	0.8928	2.4838
Urban	0.3153	1.1310	3.0855
Rural	−0.3638	0.5934	1.7275
Eastern	0.0646	0.9391	2.5653
Central	−0.0616	0.8424	2.3994
Western	0.0433	0.8900	2.4721
Female	0.1679	0.9665	2.6580
Male	−0.0227	0.8750	2.4417
Young_Grp	0.3743	1.2038	3.2538
Middle_Grp	0.0572	0.9212	2.5755
Old_Grp	−0.3032	0.6290	1.8041
Married	0.0319	0.9083	2.5299
Unmarried	−0.1113	0.7810	2.1520
No Schooling	−0.6315	0.3343	1.0237
Primary_Education	−0.1342	0.7471	2.1205
Secondary_Education	0.3150	1.1271	3.1520
Higher_Education	0.7265	1.6279	4.2421
Wealth_Grp1	−0.3669	0.5718	1.6676
Wealth_Grp2	0.0111	0.8705	2.4606
Wealth_Grp3	0.4263	1.2617	3.3837
Income_Grp1	−0.4133	0.5569	1.6331
Income_Grp2	0.0547	0.8916	2.4934
Income_Grp3	0.4053	1.2328	3.3319

Notes: This table reports the means of the literacy measures by demographics. We use sampling weights to ensure that the statistics are representative of the population. For the age groups, *Young_Grp* refers to household heads younger than 44 years old; *Middle_Grp* refers to household heads aged between 44 and 55; *Old_Grp* refers to household heads older than 60. For the education groups, *No_Schooling, Primary_Education, Secondary_Education* and *Higher_Education* mean 0, up to 9, 9–12 and more than 12 years of education, respectively. For income/wealth groups, we group the corresponding variables based on the terciles of the distribution of the values. Detailed definitions of all the variables are provided in Appendix B.

using digital finance. Considering that the mean value of the use of digital finance is 0.291, this is a sizable effect.

Focusing on the other regressors, we observe significant and positive marginal effects associated with household wealth and income. This result suggests that wealthier and higher-income households are more likely to use digital finance. A one percent increase in household wealth and income respectively lead to a 0.04 percentage point and a 0.05 percentage point rise in the probability of using digital finance.

The financial literacy index we use is widely used to measure household financial knowledge (Lusardi and Mitchell 2011, 2014;

Table 4
Digital finance usage by subgroups.

	Digital_Finance	Mobile_Payments	Online_FPs	Online_Borrowing
Nation	29.1%	28.1%	6.6%	4.4%
Urban	42.4%	41.0%	10.3%	6.8%
Rural	12.4%	11.9%	2.0%	1.3%
Eastern	32.7%	31.4%	9.2%	5.2%
Central	24.2%	23.4%	4.6%	3.0%
Western	30.3%	29.5%	5.3%	5.0%
Female	36.4%	35.8%	9.3%	5.8%
Male	27.3%	26.2%	6.0%	4.0%
Young_Grp	54.8%	53.3%	13.5%	9.4%
Middle_Grp	28.9%	27.9%	6.2%	4.0%
Old_Grp	10.4%	10.0%	2.1%	1.2%
Married	30.0%	29.0%	6.8%	4.4%
Unmarried	22.6%	22.0%	5.6%	4.1%
No_Schooling	7.6%	7.1%	1.3%	1.1%
Primary_Education	20.8%	20.1%	3.5%	2.5%
Secondary_Education	39.7%	38.7%	8.6%	6.2%
Higher_Education	68.1%	65.2%	22.4%	13.0%
Wealth_Grp1	8.4%	8.2%	1.1%	1.1%
Wealth_Grp2	26.2%	25.3%	4.6%	3.6%
Wealth_Grp3	54.4%	52.5%	14.8%	8.8%
Income_Grp1	9.3%	8.9%	1.2%	1.2%
Income_Grp2	25.5%	24.9%	3.6%	2.7%
Income_Grp3	52.6%	50.6%	15.1%	9.2%
literacy_Grp1	11.1%	10.7%	1.5%	1.0%
literacy_Grp2	43.9%	42.4%	11.7%	7.4%
literacy_Grp3	40.4%	39.1%	8.9%	6.3%

Notes: This table reports the weighted percentages of financial literacy measures by demographics. We use sampling weights to ensure that the statistics are representative of the population. For the age groups, *Young_Grp* refers to household heads younger than 44 years old; *Middle_Grp* refers to household heads aged between 44 and 55; *Old_Grp* refers to household heads older than 60. For the education groups, *No_Schooling, Primary_Education, Secondary_Education* and *Higher_Education* mean 0, up to 9, 9–12 and more than 12 years of education, respectively. For income/wealth/literacy groups, we group the corresponding variables based on the terciles of the distribution of the values. Detailed definitions of all the variables are provided in Appendix B.

Table 5
Baseline results of probit model regressions.

	(1) Digital_Finance	(2) Mobile_Payments	(3) Online_FPs	(4) Online_Borrowing
Literacy_Index	0.0269***	0.0264***	0.0090***	0.0080***
	(0.0026)	(0.0026)	(0.0018)	(0.0015)
Ln(Wealth)	0.0420***	0.0413***	0.0127***	0.0059***
	(0.0026)	(0.0026)	(0.0017)	(0.0012)
Ln(Income)	0.0504***	0.0486***	0.0236***	0.0110***
	(0.0029)	(0.0029)	(0.0024)	(0.0018)
Age	−0.0107***	−0.0103***	−0.0025***	−0.0035***
	(0.0016)	(0.0016)	(0.0009)	(0.0007)
Age^2/100	0.0036**	0.0034**	0.0005	0.0020***
	(0.0015)	(0.0015)	(0.0009)	(0.0006)
Male	−0.0194***	−0.0203***	−0.0048	0.0008
	(0.0071)	(0.0071)	(0.0043)	(0.0035)
Single_Female	0.0430***	0.0430***	0.0135	0.0076
	(0.0149)	(0.0151)	(0.0085)	(0.0071)
Married	−0.0009	−0.0014	0.0050	−0.0029
	(0.0081)	(0.0081)	(0.0049)	(0.0037)
Education	0.0057***	0.0051***	0.0034***	0.0013***
	(0.0009)	(0.0009)	(0.0006)	(0.0005)
Size_Household	0.0106***	0.0109***	0.0004	0.0019**
	(0.0017)	(0.0017)	(0.0011)	(0.0008)
Unhealthy_Ratio	−0.0837***	−0.0874***	−0.0323***	−0.0206**
	(0.0154)	(0.0154)	(0.0122)	(0.0100)
Employed	0.0204***	0.0220***	−0.0002	0.0076**
	(0.0060)	(0.0061)	(0.0040)	(0.0032)
Homeowner	−0.0695***	−0.0663***	−0.0212***	−0.0188***
	(0.0092)	(0.0092)	(0.0050)	(0.0039)
Entrepreneurship	0.0576***	0.0544***	0.0071*	0.0119***
	(0.0072)	(0.0072)	(0.0040)	(0.0031)
Party	−0.0212***	−0.0164**	−0.0097**	−0.0169***
	(0.0074)	(0.0073)	(0.0044)	(0.0037)
Ability_High1	0.0270***	0.0264***	0.0085**	0.0037
	(0.0064)	(0.0064)	(0.0040)	(0.0033)
Ability_High2	0.0336***	0.0323***	0.0086**	0.0067*
	(0.0066)	(0.0065)	(0.0043)	(0.0037)
Rural	−0.0708***	−0.0697***	−0.0185***	−0.0172***
	(0.0075)	(0.0075)	(0.0048)	(0.0038)
No_Branches	0.0032**	0.0021	0.0014	0.0001
	(0.0016)	(0.0016)	(0.0009)	(0.0007)
Broadband_Access	0.0075	0.0172	−0.0080	−0.0015
	(0.0238)	(0.0242)	(0.0137)	(0.0101)
Ln(GRP_PC)	0.0222**	0.0228**	0.0035	0.0006
	(0.0103)	(0.0105)	(0.0062)	(0.0046)
(△Y/△X) / E(Y)	9.25%	9.39%	13.62%	18.31%
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788
pseudo R^2	0.3352	0.3278	0.2513	0.2125

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Lusardi and de Bassa Scheresberg 2013; Grohmann et al., 2018). However, it may be a concern that this index, serving as a proxy for personality traits, could also capture cognitive ability. We therefore consider this concern in Table 5 by including additional controls (*Ability_High1* and *Ability_High2*) for cognitive ability. We find that these proxies for cognitive ability are often significant and have the expected signs that cognitive ability has a positive effect on the use of digital finance. Notably, if our financial literacy index only reflects cognitive ability, then we would no longer see any significant effect of the financial literacy index on the use of digital finance in our regressions.[7] In addition, we find that the use of digital finance significantly increases with household education. Education has a positive impact on the use of digital finance but does not necessarily reflect financial knowledge or cognitive ability. The significant and positive marginal effects of education indicate its potential role in overcoming barriers to the use of digital finance owing to ignorance and misperceptions (Haliassos and Bertaut 1995).

We also find that employment and entrepreneurship positively impact the use of digital finance. Nonetheless, households that own their homes are less inclined to use digital finance, which may indicate a preference for investing in property relative to other types of financial assets. We observe that the likelihood of using digital finance is significantly lower among men than women (particularly among those who are single), communist party members than non-party members, and those living with unhealthy family members and smaller family sizes than those with healthy family members and larger family sizes. Following Finke et al. (2017), we test the influence of age and find that age is negatively and significantly related to the use of digital finance, whereas the square of age is significantly positively related. This finding suggests a U-shaped relationship between age and the use of digital

[7] Our results are robust when we estimate our models without accounting for cognitive ability, which shows the significantly positive marginal effects associated with the financial literacy index on the use of digital finance. For brevity, these results are not reported, but they are available upon request.

finance. However, when looking at the magnitudes of the single and squared terms, we find that the turning point of the U-shaped relationship between age and the use of digital finance (i.e., the quadratic graph goes from downward to upward sloping) is greater than 100.[8] Therefore, age overall has a negative impact on the use of digital finance. The negative marginal effects of *Rural* and the positive marginal effects of *GRP_PC* and *No_Branches* show that the use of digital finance is higher in urban areas and regions with higher income per capita and financial outreach than in rural areas and regions with lower income per capita and financial outreach.

Columns 2–4 of Table 5 show the relationships between financial literacy and the use of mobile payments, online financial products, and online borrowing. Specifically, even after accounting for demographic, socio-economic, and geographic factors, financial literacy has a significantly positive impact on the use of all of them. The corresponding marginal effects on the use of mobile payments, online financial products, and online borrowing are 2.64% (column 2), 0.9% (column 3), and 0.8% (column 4), respectively. The adoption rates of mobile payments, online financial products, and online borrowing vary significantly with mean values of 0.281, 0.066, and 0.044, respectively. Due to these disparities, we cannot directly compare the effects of financial literacy on these three forms of digital finance by analyzing their marginal effects. Instead, we use the mean values of these three forms of digital finance as reference levels to assess the impact of financial literacy evaluated at these mean values.[9] Specifically, a one-unit increase in the financial literacy index enhances the probability of using mobile payments, online financial products, and online borrowing by 9.39%, 13.62%, and 18.31%, respectively, when evaluated at these mean values. These figures reveal that financial literacy plays a more important role in promoting the use of online borrowing and online financial products than mobile payments. The reason may be that financial literacy has a greater influence on the adoption of more complex digital finance products, such as online borrowing and online financial products, than mobile payments, which are accessible, user-friendly, and less risky. The signs and significance of the other control variables are generally similar to those in our baseline models (column 1).

4.2. Robustness tests

We conduct a series of robustness tests to check the validity of our results. These tests use alternative measures of financial literacy, employ an IV approach, and consider the influence of peer effects and voluntary self-exclusion.

4.2.1. Different measures of financial literacy

We first verify whether our results are robust to different proxies for financial literacy. Panels A and B of Table 6 present the estimates based on *Literacy_Score1* and *Literacy_Score2,* respectively. In line with our main results, financial literacy is significantly and positively associated with the use of digital finance regardless of the different measures used. Panel C further measures financial knowledge based on whether the respondent has taken any finance–related classes. Specifically, *Financial_Class*, a dummy variable, is equal to 1 if the respondent has attended an economics and/or finance class in the past and 0 if otherwise. The finding further confirms that financial literacy increases the use of digital finance.

Similar results are found for the use of mobile payments (column 2), online financial products (column 3), and online borrowing (column 4). In addition, financial literacy has a higher impact on online borrowing and online financial products than on mobile payments when evaluated at the mean values of these three forms of digital finance. For example, as shown in Panel A, the impacts of financial literacy for online financial products and online borrowing are 25.11% and 18.99%, respectively, which are greater than that for mobile payments (11.85%). These results confirm the importance of financial literacy in the adoption of highly complicated financial products.

As for the other explanatory variables, the estimates are qualitatively similar to those reported in Table 5, but we do not report them for brevity. In summary, these results suggest that our main findings are robust to the use of different financial literacy indicators.

4.2.2. IV estimation

Previous studies often considered financial literacy to be endogenous (van Rooij et al. 2011). Although our baseline specification controls for different demographic, socio-economic, and geographic factors, unobservable factors may drive our results. For instance, households with high levels of financial knowledge may exhibit great optimism, potentially making them inclined to engage with innovative digital finance solutions. Additionally, digital financial tools can potentially elevate users' financial literacy by offering accessible, personalized, and engaging educational content. Such digital tools may also encourage users to seek relevant financial information or acquire knowledge through experience, thereby helping them understand financial concepts and adopt best practices. Unobservable factors and simultaneity may result in a spurious relationship between financial literacy and the use of digital finance.

We employ an IV approach to infer the causal impact of financial knowledge on the use of digital finance to overcome these endogeneity concerns. Specifically, following van Rooij et al. (2011), we first instrument respondents' financial literacy by the education levels of their parents, which are measured as years of schooling. The intuition is that parents' education is unlikely to change as a result of the financial behavior of their children but is likely to be correlated with their children's financial knowledge. Second, inspired by Bucher-Koenen and Lusardi (2011), we use neighborhood financial literacy as another instrument for household financial knowledge. In particular, we divide local neighborhoods into three groups according to their total wealth and calculate the mean financial literacy value for each group (i.e., *Wealth_Grp1, Wealth_Grp2*, and *Wealth_Grp3*). The rationale is that an individual's financial knowledge is likely to be linked with that of households belonging to the same community and similar wealth groups although this linkage would not directly affect a household's adoption of digital finance. Third, we use the respondent's social identity as an instrument for financial literacy. Specifically, we use the respondent's place of birth, which is recorded on his or her household registration book or "*hukou bu*,"[10] dummies for the decade in which the respondent was born (e.g., the 1970s, 1980s) and interaction terms between them to reflect the person's social identity (Afridi et al., 2015). In theory, householders' places and dates of birth are reasonably exogenous (and are out of their control). However, they strongly influence individuals' social identities, which might explain cross-sectional differences in individuals' financial literacy.

We then re-estimate our baseline models using the instrumental approach. Panels A, B, and C of Table 7 present the IV probit estimates when the financial literacy index is instrumented by the education levels of the respondent's parents, neighborhood financial literacy, and the respondent's social identity, respectively. Column 1 in Panels A and B reports the coefficients from our first-stage regression of financial

[8] For example, in column 1, given that the magnitudes of the marginal effects associated with the single term (Age) and the squared term (Age^2/100) are −0.0107 and 0.0036, respectively, the turning point of age in the quadratic graph is 148.6=0.0107/(2×0.0036/100).

[9] In other words, we aim to find how the marginal effects compare relatively to the vastly different means. Notably, standardizing binary outcome variables may render the results meaningless.

[10] The Chinese hukou system, also known as the household registration system, was introduced in 1958. Every citizen must be registered at birth with this basic demographic information.

Table 6
Probit model regressions: alternative measures of financial literacy.

	(1)	(2)	(3)	(4)
Panel A	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Score1	0.0349***	0.0333***	0.0166***	0.0083***
	(0.0029)	(0.0029)	(0.0018)	(0.0014)
(△Y/△X) / E(Y)	12.00%	11.85%	25.11%	18.99%
Other Control Variables	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788
pseudo R^2	0.3364	0.3286	0.2573	0.2129
Panel B	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Score2	0.0215***	0.0209***	0.0091***	0.0043***
	(0.0015)	(0.0015)	(0.0010)	(0.0008)
(△Y/△X) / E(Y)	7.39%	7.44%	13.77%	9.84%
Other Control Variables	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788
pseudo R^2	0.3396	0.3320	0.2575	0.2125
Panel C	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Financial_Class	0.1953***	0.1772***	0.0728***	0.0309***
	(0.0380)	(0.0367)	(0.0142)	(0.0115)
(△Y/△X) / E(Y)	67.16%	63.04%	110.14%	70.71%
Other Control Variables	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788
pseudo R^2	0.3318	0.3243	0.2517	0.2093

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

literacy on the education level of the respondent's parents and neighborhood financial literacy, respectively. The coefficients on both IVs are significantly positive at the 1% level, which satisfies the relevance condition. Individuals whose parents are well-educated tend to have great financial knowledge. Additionally, a respondent's understanding of financial matters is closely related to his or her neighborhood. These results indicate possible channels through which financial knowledge may be acquired. Panel C does not include the results of the first-stage regression owing to an excessive number of instruments, which consist of dummies for householders' places and decades of birth and their interactions. However, regardless of the instruments used, the first-stage F-statistics are greater than the rule of thumb of 10, suggesting that our instruments are valid and have high explanatory power (Stock and Yogo 2005). In addition, Wald tests for the exogeneity of the instrumented variables reject the null hypothesis of no endogeneity.

Columns 2–5 of Table 7 present the second-stage regression results of digital finance, mobile payments, online financial products, and online borrowing, respectively. The results again show that financial literacy has a positive and statistically significant impact regardless of the instruments employed, confirming the importance of financial literacy in promoting the use of digital finance. In particular, a 10 percentage point increase in financial literacy enhances the probability of using digital finance by a range of 1.71 (Panel B) to 5.71 (Panel C) percentage points (column 2). We also calculate the marginal effects of financial literacy, evaluated at the mean values of these three types of digital finance, to compare the impact of financial literacy on the three forms of digital finance. In line with the baseline estimation results, financial literacy has a greater influence on online borrowing and online financial products than mobile payments, except for the results in Panel B.

In unreported results, we re-estimate the empirical models using the two-stage least-squares IV approach. The coefficients on *Literacy_Index* are still significant and positive for the different forms of digital finance, that is, mobile payments, online financial products, and online borrowing. In particular, a 10% increase in financial literacy is associated with an increase in the probability of using digital finance, ranging from 2.28 to 7.30 percentage points. Moreover, the Kleibergen-Paap rk LM and the Anderson tests for instrument validity have significant p-values (i.e., p-values less than 0.05), rejecting the null hypothesis that the equation is under-identified. The tests suggest that our instruments are adequate for identifying equations. In short, our main results are robust in accounting for the potential endogeneity of financial literacy: people with higher financial literacy are more likely to use digital finance than those with less financial literacy.

4.2.3. *Peer effects*

Previous research showed that the experiences of peers can influence respondents' portfolio choices (Hong et al., 2004; Brown et al., 2008). Our IV results also suggest that interactions with individuals with close ties, such as family and neighbors, are a potential channel for acquiring financial knowledge. In this case, information about using digital finance could spread through peer groups via word of mouth. This subsection investigates whether our estimates hold after controlling for peer effects of using digital finance. To this end, we construct a new financial literacy index in Table 8 by subtracting peer financial literacy from the respondent's financial literacy index. Specifically, we first construct 24 subgroups based on the interaction between age (six age groups: 18–30, 31–40, 41–50, 51–60, 61–70, and >70) and education (four education groups as shown in Table 3) in a given province. Then, we calculate the average value of the financial literacy index as a proxy for peers' financial literacy. After considering peer group effects, the marginal effects of financial literacy remain significantly positive. In addition, the marginal effects of financial literacy relative to their mean values are more pronounced for online borrowing (16.93%) and online financial products (12.86%) than mobile payments (8.64%).

4.2.4. *Voluntary self-exclusion*

Empirical analyses to date have assumed that the exclusion of respondents from digital finance is involuntary, resulting from a lack of

Table 7
Robustness check: instrumental variable probit model regressions.

	(1)	(2)	(3)	(4)	(5)
Panel A	**First Stage**	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Index		0.4440***	0.4290***	0.1232***	0.1078***
		(0.0408)	(0.0408)	(0.0252)	(0.0210)
Parents' Education	0.0183***				
	(0.0020)				
(△Y/△X) / E(Y)		152.68%	152.61%	186.38%	246.68%
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
P-value Exogeneity		0.000***	0.000***	0.000***	0.000***
First Stage F-stat	81.180				
N	15,862	15,862	15,862	15,862	15,862
Panel B	**First Stage**	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Index		0.1714***	0.1713***	0.0377*	0.0336**
		(0.0311)	(0.0319)	(0.0208)	(0.0158)
Neighbourhood Financial Literacy	0.1635***				
	(0.0198)				
(△Y/△X) / E(Y)		58.94%	60.94%	57.03%	76.89%
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
P-value Exogeneity		0.000***	0.000***	0.000***	0.000***
First Stage F-stat		69.280	131.42		
N	19,364	19,364	19,364	19,364	19,364
Panel C	**First Stage**	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Index		0.5711***	0.5649***	0.2071***	0.1425***
		(0.0163)	(0.0163)	(0.0117)	(0.0100)
Hukou_Decade_Dummy					
(△Y/△X) / E(Y)		196.39%	200.96%	313.31%	326.09%
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
P-value Exogeneity		0.000***	0.000***	0.000***	0.000***
First Stage F-stat	41.500				
N	19,788	19,788	19,788	19,788	19,788

Notes: The table reports marginal effects and standard errors (in parentheses). We estimate all the specifications using the instrumental variable (IV) probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. The p-value exogeneity test is the Wald test of exogeneity of the instruments. The F-statistics of the first stage regression of *Literacy_Index* are also reported. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

financial knowledge. However, some households may have access to digital finance services, but they may opt not to use them as they perceive no need for them, resulting in voluntary exclusion from digital finance.[11] We consider respondents to be voluntarily self-excluded from using digital finance if they answered "no need or no interest" to the follow-up question "Why don't you use digital finance?" Specifically, we construct a dummy variable (*Self-Exclusion*) which is equal to 1 if the respondent answered "no need or no interest" and 0 if otherwise. In Panel A of Table 9, we include the *Self-Exclusion* variable as a control variable in our regressions. For brevity, we only report the probit estimates of the financial literacy and self-exclusion variables. We find that the marginal effect of financial literacy on the use of digital finance remains significantly positive. Moreover, the marginal effects of financial literacy concerning their mean values are more prominent for online borrowing and online financial products than for mobile payments. Notably, *Self-Exclusion* has a significantly negative impact on the use of digital finance, confirming that households who perceived no need or interest in digital finance are indeed less likely to use digital finance.[12] In Panel B, we further removed households that voluntarily excluded themselves from digital finance to alleviate self-selection bias, and the results remain qualitatively unchanged.

5. Further tests

5.1. Financial literacy working mechanisms

Thus far, our findings suggest that increasing financial literacy can facilitate the use of digital finance. The literature suggests that the cost of acquiring information, lack of trust in new technology, and risk aversion could be potential obstacles to using digital finance.

First, financial literacy equips individuals with basic financial concepts, such as interest rates, asset allocation, diversification, and financial risk. This level of proficiency can reduce the costs of obtaining information related to the use of digital finance. For example, financial literacy can assist households in collecting and processing economic information from diverse sources, including the Internet. Financial literacy, in turn, can aid households in making informed decisions about digital financial services and products, which can be complex and confusing (Wang et al., 2021; Niu et al., 2020).

Second, financial literacy can bolster consumers' trust and confidence in using digital financial services (Hansen 2012; Malady 2016).

[11] We do not exclude from the sample households those who voluntarily self-exclude from using digital finance because households, which do not need or are not interested in digital finance, may lack sufficient financial knowledge, and thus, they feel that digital finance is not necessary. To the best of our knowledge, this study is the first to consider voluntary self-exclusion when examining the use of digital finance. This issue has been largely ignored in previous research. We keep the voluntary self-exclusion sample in our main regressions to make easy comparisons with prior research.

[12] The self-exclusion variable is omitted in column 3 because of collinearity.

Table 8
Probit model regressions: taking peer effects into consideration.

	(1) Digital_Finance	(2) Mobile_Payments	(3) Online_FPs	(4) Online_Borrowing
Literacy_Index	0.0249***	0.0243***	0.0085***	0.0074***
	(0.0026)	(0.0026)	(0.0018)	(0.0015)
Ln(Wealth)	0.0422***	0.0416***	0.0128***	0.0059***
	(0.0026)	(0.0026)	(0.0017)	(0.0012)
Ln(Income)	0.0506***	0.0488***	0.0236***	0.0111***
	(0.0029)	(0.0030)	(0.0024)	(0.0018)
Age	−0.0112***	−0.0108***	−0.0026***	−0.0035***
	(0.0016)	(0.0016)	(0.0009)	(0.0007)
Age^2/100	0.0038**	0.0036**	0.0005	0.0021***
	(0.0015)	(0.0015)	(0.0009)	(0.0007)
Male	−0.0202***	−0.0211***	−0.0051	0.0006
	(0.0071)	(0.0071)	(0.0043)	(0.0035)
Single_Female	0.0431***	0.0432***	0.0134	0.0076
	(0.0149)	(0.0151)	(0.0085)	(0.0071)
Married	−0.0010	−0.0014	0.0050	−0.0029
	(0.0081)	(0.0081)	(0.0049)	(0.0037)
Education	0.0076***	0.0069***	0.0041***	0.0019***
	(0.0009)	(0.0009)	(0.0006)	(0.0005)
Size_Household	0.0105***	0.0108***	0.0004	0.0018**
	(0.0017)	(0.0017)	(0.0011)	(0.0008)
Unhealthy_Ratio	−0.0845***	−0.0883***	−0.0325***	−0.0209**
	(0.0154)	(0.0154)	(0.0122)	(0.0100)
Employed	0.0213***	0.0229***	0.0001	0.0078**
	(0.0060)	(0.0061)	(0.0040)	(0.0032)
Homeowner	−0.0695***	−0.0663***	−0.0212***	−0.0188***
	(0.0092)	(0.0092)	(0.0050)	(0.0039)
Entrepreneurship	0.0574***	0.0541***	0.0070*	0.0118***
	(0.0072)	(0.0072)	(0.0040)	(0.0031)
Party	−0.0204***	−0.0156**	−0.0097**	−0.0168***
	(0.0074)	(0.0073)	(0.0044)	(0.0037)
Ability_High1	0.0272***	0.0267***	0.0085**	0.0038
	(0.0064)	(0.0064)	(0.0040)	(0.0033)
Ability_High2	0.0341***	0.0329***	0.0088**	0.0068*
	(0.0066)	(0.0065)	(0.0043)	(0.0037)
Rural	−0.0717***	−0.0706***	−0.0188***	−0.0175***
	(0.0075)	(0.0075)	(0.0048)	(0.0038)
No_Branches	0.0034**	0.0022	0.0014*	0.0002
	(0.0016)	(0.0016)	(0.0009)	(0.0007)
Broadband_Access	0.0075	0.0171	−0.0082	−0.0017
	(0.0239)	(0.0243)	(0.0138)	(0.0102)
Ln(GRP_PC)	0.0227**	0.0232**	0.0037	0.0007
	(0.0104)	(0.0106)	(0.0062)	(0.0047)
(△Y/△X) / E(Y)	8.56%	8.64%	12.86%	16.93%
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788
pseudo R^2	0.3345	0.3271	0.2510	0.2119

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Financial knowledge enhances households' awareness of new financial services, thereby enabling individuals to evaluate the costs, fees, and risks associated with various digital financial services. Moreover, financial knowledge helps individuals recognize the benefits of digital financial services, such as convenience, functionality, and accessibility, which collectively contribute to building trust. By contrast, individuals with low financial literacy may hesitate to use digital financial services owing to a lack of trust. A survey conducted in Cyprus in 2018 found that financially illiterate consumers are less likely to trust Internet banking and exhibit lower confidence in their digital and financial skills (Andreou and Anyfantaki 2021).

Third, financial literacy can reduce risk aversion and increase tolerance to digital finance–related risks. New technologies often face difficulty in appealing to risk-averse individuals (Han et al., 2019). According to choice bracketing theory (Read et al.1999; Dohmen et al., 2010), people tend to behave in a risk-averse manner if they fail to incorporate future considerations in their decision-making or to perceive the broad context of their choices. Narrow bracketing of choices can lead to overly cautious decision-making. Financial literacy may enhance users' risk awareness, help them identify and manage digital financial risks, navigate digital platforms, and conduct secure transactions. Furthermore, financial knowledge can help consumers protect themselves from fraud and other risks associated with digital financial services and safeguard their personal and financial information.

In this section, we examine various channels through which financial literacy may affect the use of digital finance. Specifically, we first examine the extent to which financial literacy can enhance households' access to financial information online owing to a reduction in the costs associated with information acquisition. Second, we test whether financial literacy increases households' trust in the use of new technologies, thereby facilitating their adoption of digital finance. Third, we test whether financial literacy increases households' tolerance for financial risks, which may also lead to greater use of digital finance.

Table 10 presents the estimation results of *Watch_Fin_Online, Trust*, and *Risk_Averse* serving as mediator variables for the impact of financial

Table 9
Probit model regressions: taking voluntary self-exclusion into consideration.

	(1)	(2)	(3)	(4)
Panel A	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Index	0.0270***	0.0265***	0.0095***	0.0080***
	(0.0026)	(0.0026)	(0.0019)	(0.0015)
Self-Exclusion	−0.0496***	−0.0477***		−0.0275*
	(0.0184)	(0.0184)		(0.0146)
(△Y/△X) / E(Y)	9.28%	9.43%	14.37%	18.31%
Other Control Variables	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,788	19,788	19,040	19,788
pseudo R^2	0.3356	0.3281	0.2466	0.2132
Panel B	**Digital_Finance**	**Mobile_Payments**	**Online_FPs**	**Online_Borrowing**
Literacy_Index	0.0280***	0.0275***	0.0095***	0.0084***
	(0.0027)	(0.0027)	(0.0019)	(0.0015)
(△Y/△X) / E(Y)	9.63%	9.78%	14.37%	19.22%
Other Control Variables	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
N	19,040	19,040	19,040	19,040
pseudo R^2	0.3337	0.3262	0.2466	0.2086

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

literacy on the use of digital finance. Specifically, in columns 1–3 of Panel A, we regress *Watch_Fin_Online, Trust*, and *Risk_Averse* on financial literacy while controlling for all the demographic, socio-economic, and geographic factors, respectively. See Appendix B for detailed definitions of these three variables. As expected, the coefficients on *Literacy_Index* for *Watch_Fin_Online* and *Trust* are significantly positive, whereas the coefficient for *Risk_Averse* is significantly negative. These results suggest that households with greater financial literacy tend to access more financial news and information online, have greater trust in new things and people, and are less risk-averse than those with less financial literacy.

Furthermore, we examine the extent to which financial literacy affects the use of digital finance by controlling for these three moderator variables. Panel B of Table 10 shows the results. In columns 2–4, we include each of these three moderator variables individually. Our analysis reveals that the marginal effects of *Watch_Fin_Online* and *Trust* are significantly positive, whereas the marginal effect of *Risk_Averse* is significantly negative. The findings suggest that promoting online access to financial information can increase the use of digital finance. Moreover, increased trust and risk tolerance associated with new technology will also lead to increased use of digital finance. We find that the marginal effects of financial literacy are still significant after accounting for these moderators in our regressions. However, their magnitudes are smaller than those in column 1 (without moderator variables). For example, the marginal effects associated with financial literacy in columns 2–4 drop by approximately 11.9%, 1.1%, and 3.7%, respectively, compared with the marginal effect in column 1 (2.69%). These results suggest that *Watch_Fin_Online, Trust*, and *Risk_Averse* partially mediate the effect of financial literacy on the use of digital finance. Sobel tests (Sobel 1982) reject the null hypothesis of no mediation effects.[13] In column 5, we include all three moderators in the regression and find that the marginal effects of all three moderators have signs consistent with our expectations and are significant at the 1% level. The marginal effect associated with financial literacy remains positive and significant, whereas its magnitude decreases by approximately 15.6%, that is, from 2.69% to 2.27%.

[13] Sobel (1982) proposed the Sobel test. This test examines whether a mediator carries the influence of a given independent variable to a dependent variable.

In Panels C, D, and E of Table 10, we repeat all the exercises as in Panel B for the three forms of digital finance, namely, mobile payments, online financial products, and online borrowing, respectively. After adding these moderators into our regressions, the marginal effects associated with financial literacy remain positive and significant at the 1% level, although their magnitudes are smaller than those in column 1 (with an absence of moderator variables). For example, the figures in column 5 of Panels C (*Mobile_Payments*), D (*Online_FPs*), and E (*Online_Borrowing*) show that the marginal effects associated with financial literacy fall by 15.2%, 18.9%, and 12.5%, respectively, compared with the marginal effects in column 1. The results suggest that *Watch_Fin_Online, Trust*, and *Risk_averse* partially mediate the effects of financial literacy on the use of these digital financial products.

In short, the mechanism analysis suggests that *Watch_Fin_Online, Trust*, and *Risk_Averse* are suitable mediator variables. In other words, financial literacy plays a vital role in promoting the use of digital finance by enhancing access to online information, boosting digital trust, and increasing risk tolerance for digital finance.

5.2. Heterogeneous effects of financial literacy

5.2.1. Variation by wealth and income

Digital finance use is influenced by household wealth and income. This subsection further investigates how the effect of financial literacy on the use of digital finance varies across households with different wealth or income levels. We classify households into three groups based on their total wealth and income in Panels A and B of Table 11. Specifically, in column 1 (3), we consider a household to have a low (high) level of wealth or income if its total wealth or income lies in the bottom (top) third of the distribution of the variable in the data sample. The remaining households form the medium level of wealth or income group. In all the wealth groups, the marginal effects associated with financial literacy are always positive and significant. Considering the significant discrepancies in the use of digital finance across groups, we also estimate the marginal effects of financial literacy, which were evaluated at their respective mean values. Financial literacy has the greatest effects on the use of digital finance for families with the lowest levels of wealth (16.17%) and income (18.28%), followed by households with medium levels of wealth (11.40%) and income (11.95%), and the least for those with the highest levels of wealth (6.7%) and income (5.63%). However, low-wealth/income households are less likely to

Table 10
Further mechanism tests.

	(1)	(2)	(3)	(4)	(5)
Panel A	**Watch_Fin_Online**	**Trust**	**Risk Averse**		
Literacy_Index	0.0161***	0.0086***	−0.0148***		
	(0.0024)	(0.0028)	(0.0036)		
Other Control Variables	Yes	Yes	Yes		
Province Fixed Effects	Yes	Yes	Yes		
N	19,788	19,788	19,788		
Pseudo R^2	0.2186	0.0181	0.0317		
Panel B			**Digital Finance**		
Literacy_Index	0.0269***	0.0237***	0.0266***	0.0259***	0.0227***
	(0.0026)	(0.0025)	(0.0026)	(0.0026)	(0.0025)
Watch_Fin_Online		0.1556***			0.1514***
		(0.0068)			(0.0069)
Trust			0.0299***		0.0239***
			(0.0064)		(0.0063)
Risk Averse				−0.0463***	−0.0350***
				(0.0053)	(0.0052)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788	19,788
Pseudo R^2	0.3352	0.3588	0.3362	0.3385	0.3616
Sobel Test Z(p)		5.460(0.000)	2.457(0.014)	8.852(0.000)	
Panel C			**Mobile_Payments**		
Literacy_Index	0.0264***	0.0232***	0.0262***	0.0255***	0.0224***
	(0.0026)	(0.0025)	(0.0026)	(0.0026)	(0.0025)
Watch_Fin_Online		0.1516***			0.1477***
		(0.0067)			(0.0067)
Trust			0.0245***		0.0189***
			(0.0065)		(0.0064)
Risk Averse				−0.0439***	−0.0327***
				(0.0053)	(0.0052)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788	19,788
Pseudo R^2	0.3278	0.3511	0.3284	0.3308	0.3533
Sobel Test Z(p)		5.459(0.000)	2.378(0.174)	8.750(0.000)	
Panel D			**Online_FPs**		
Literacy_Index	0.0090***	0.0078***	0.0088***	0.0086***	0.0073***
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Watch_Fin_Online		0.0555***			0.0534***
		(0.0036)			(0.0036)
Trust			0.0175***		0.0149***
			(0.0035)		(0.0034)
Risk Averse				−0.0209***	−0.0147***
				(0.0032)	(0.0031)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788	19,788
Pseudo R^2	0.2513	0.2788	0.2538	0.2557	0.2832
Sobel Test Z(p)		5.422(0.000)	2.506(0.012)	7.951(0.000)	
Panel E			**Online_Borrowing**		
Literacy_Index	0.0080***	0.0073***	0.0079***	0.0078***	0.0070***
	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
Watch_Fin_Online		0.0350***			0.0336***
		(0.0030)			(0.0030)
Trust			0.0083***		0.0067**
			(0.0031)		(0.0031)
Risk Averse				−0.0141***	−0.0103***
				(0.0026)	(0.0026)
Other Control Variables	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	19,788	19,788	19,788	19,788	19,788
Pseudo R^2	0.2125	0.2376	0.2138	0.2172	0.2411
Sobel Test Z(p)		5.333(0.000)	2.135(0.033)	6.595(0.000)	

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. Under the null hypothesis of no mediation effect, the Sobel tests are used to test whether a mediator carries the influence of a given independent variable to a dependent variable. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 11
Probit model regressions: considering the heterogeneous effects of financial literacy based on demographic and socio-economic factors.

	(1)	(2)	(3)
Panel A	**Low_Wealth**	**Mid_Wealth**	**High_Wealth**
Literacy_Index	0.0136***	0.0299***	0.0365***
	(0.0028)	(0.0046)	(0.0058)
(△Y/△X) / E(Y)	16.17%	11.40%	6.70%
Other Control Variables	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes
N	6596	6596	6596
pseudo R^2	0.2925	0.2221	0.2390
Panel B	**Low_Income**	**Mid_Income**	**High_Income**
Literacy_Index	0.0170***	0.0305***	0.0296***
	(0.0026)	(0.0047)	(0.0059)
(△Y/△X) / E(Y)	18.28%	11.95%	5.63%
Other Control Variables	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes
N	6596	6596	6596
pseudo R^2	0.3054	0.2200	0.2302
Panel C	**Young_Age**	**Middle_Age**	**Old_Age**
Literacy_Index	0.0168***	0.0341***	0.0168***
	(0.0031)	(0.0038)	(0.0031)
(△Y/△X) / E(Y)	3.06%	11.78%	16.18%
Other Control Variables	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes
N	3847	7728	8213
pseudo R^2	0.3041	0.2394	0.2704
Panel D	**Male**	**Female**	
Literacy_Index	0.0257***	0.0336***	
	(0.0028)	(0.0062)	
(△Y/△X) / E(Y)	9.41%	9.22%	
Other Control Variables	Yes	Yes	
Province Fixed Effects	Yes	Yes	
N	15,849	3939	
pseudo R^2	0.3284	0.3484	

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

access digital finance than high-wealth/income ones (Table 4). Although low-wealth/income families tend to have higher costs of accessing information and lower levels of trust and tolerance regarding financial risks, financial literacy can assist these families in overcoming these obstacles. Therefore, promoting financial literacy among poor households may be an effective means to increase the adoption and use of digital financial services, which in turn could help bridge the digital divide between the rich and the poor.

5.2.2. Variation by age and gender

Panels C and D of Table 11 further explore whether the impact of financial knowledge on the use of digital finance varies with age and gender, respectively. In Panel C, we split the sample into three groups by age: young (18–44 years old), middle-aged (45–59 years old), and old-aged (older than 59 years). We find that the marginal effects associated with financial literacy are all positive and significant in the three different age groups. However, when considering the mean values of digital finance use, the impacts of financial literacy are the highest for old-aged people (16.18%), followed by middle-aged (11.78%) and young adults (3.06%). This result suggests the vital role of financial knowledge in encouraging the old-aged to embrace digital finance. This case may be related to the role financial literacy plays in mitigating barriers faced by the elderly. Compared with young adults, older individuals often encounter higher costs in acquiring information, have less trust in adopting new technologies, and are more risk-averse. In Panel D, when considering the mean values of digital finance use, the marginal effects of financial literacy are similar for women (9.22%) and men (9.41%), and both are positive and significant.

Table 12
Probit model regressions: considering the heterogeneous effects of financial literacy based on geographic factors.

	(1)	(2)	(3)
Panel A	**Rural**	**Urban**	
Literacy_Index	0.0168***	0.0341***	
	(0.0031)	(0.0038)	
(△Y/△X) / E(Y)	13.57%	8.05%	
Other Control Variables	Yes	Yes	
Province Fixed Effects	Yes	Yes	
N	7887	11,901	
Pseudo R^2	0.2489	0.3001	
Panel B	**Western**	**Central**	**Coastal**
Literacy_Index	0.0286***	0.0214***	0.0299***
	(0.0054)	(0.0042)	(0.0041)
(△Y/△X) / E(Y)	9.44%	8.83%	9.16%
Other control variables	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
N	4364	6705	8719
Pseudo R^2	0.3428	0.3219	0.3384

Notes: The table reports marginal effects and standard errors (in parentheses). All the specifications were estimated using the probit estimator. Test statistics and standard errors of all the variables in the regressions are clustered at the community level. (△Y/△X)/E(Y) is the marginal effect associated with *Literacy_Index* evaluated at the mean values of the different forms of digital finance. See Appendix B for detailed definitions of all the variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

5.2.3. Variation by region

China is a vast nation with significant rural and urban disparities (Huang et al., 2008). Table 4 shows that the use of digital finance is much higher among urban than rural families. This subsection takes a close look at the possible rural–urban differences in the relationship between financial literacy and the use of digital finance. To this end, we divide the whole sample into rural and urban regions. Panel A in Table 12 shows that financial literacy has significant and positive marginal effects on rural and urban families. However, when considering the mean values of digital finance use, the marginal effects of financial literacy are higher for rural families (13.57%) than urban families (8.05%). This finding implies that promoting financial knowledge among rural households would lead to greater adoption of digital financial services in rural areas than in urban areas. In Panel B, we divide the sample into three groups according to household places of residence: coastal, central, and western regions. We find that in all the specifications, the marginal effects associated with financial literacy are always positive and significant. When considering the mean values of digital finance, the marginal effects are slightly higher in western regions (9.44%, column 1) than in coastal (9.16%, column 3) and central (8.83%, column 2) regions.

6. Conclusions

This study uses CHFS data to investigate the impact of financial literacy on the use of digital finance in China, which has the largest unbanked population and yet the world's largest fintech market (Guariglia and Yang 2016; Demirguc-Kunt et al., 2018). We find that financial literacy plays a significant role in promoting the use of digital financial services despite the low level of financial knowledge among Chinese households. Overall, a one standard deviation increase in financial literacy raises the probability of using digital finance by 2.87 percentage points. Using the mean values of three forms of digital finance as reference levels, we find that a one-unit increase in the

financial literacy index increases the probability of using mobile payments, online financial products, and online borrowing by 9.39%, 13.62%, and 18.31%, respectively. These results show that the impact of financial literacy is greater for more sophisticated financial products such as online borrowing and online financial products than for mobile payments.

Furthermore, we explore different mechanisms by which financial literacy promotes the use of digital finance. Our findings confirm the critical role of financial literacy in enhancing access to online financial information, promoting digital trust, and reducing risk aversion, leading to increased use of digital finance. Last, a heterogeneity analysis indicates that financial literacy plays a more important role for disadvantaged groups, such as families with low levels of wealth and income, the elderly, and rural residents, than their counterparts, illustrating the promising role of financial literacy in closing the digital divide.

Digital finance in emerging markets has great potential to address the financial needs of underserved population segments, including the unbanked, startups, and micro, small and medium-sized enterprises (MSMEs), by providing them with solutions for essential aspects of their lives and businesses, such as payments and credit. However, great financial knowledge is necessary to understand the risks and benefits of various digital financial services and products. As financial illiteracy spreads in emerging markets, such as China, developing effective financial education initiatives and helping customers navigate unfamiliar and potentially complex digital financial products are vital to developing responsible digital financial practices, thereby achieving equitable financial inclusion in the digital age. In particular, the authorities should develop and implement national strategies to promote digital financial education and specifically tailored programs that target vulnerable and disadvantaged groups, including the less educated, the elderly, the rural, and the poor.

CRediT authorship contribution statement

Junhong Yang: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Funding acquisition, Project administration, Visualization, Supervision. **Yu Wu:** Conceptualization, Methodology, Resources, Formal analysis, Data curation, Project administration, Supervision. **Bihong Huang:** Conceptualization, Project administration, Resources, Writing – review & editing.

Data availability

The authors do not have permission to share data.

Appendix A

A1. Questions in the CHFS related to financial literacy

The answers to the following three questions were used to calculate our composite index of financial literacy (*Literacy_Index*). The three questions concern the following concepts: numeracy and capacity to perform calculations related to interest rates, such as compound interest (Quiz_Interest); understanding of inflation (Quiz_Inflation); and understanding of financial risk (Quiz_Risk).

Quiz_Interest (H3105): Suppose you have 100 yuan and a bank's interest rate is 4% per year. If you deposit this money in the bank for 1 year, how much (the principal and interest earned) will you have in 1 year's time?

1. Less than 104 yuan
2. Equal to 104 yuan
3. More than 104 yuan
4. Do not know

Quiz_Inflation (H3106): Suppose the annual interest rate of your bank is 5% and the inflation rate is 3%. If you deposit 100 yuan in the bank, after 1 year, how much will you be able to buy with the money?

1. More than you could buy a year ago
2. The same as you could buy a year ago
3. Less than you could buy a year ago
4. Do not know

Quiz_Risk (H3111): Which investment do you think is riskier in general when you buy a stock or equity funds?

1. Stocks
2. Equity funds
3. Never heard of "stocks"
4. Never heard of "equity funds"
5. Never heard of either

A2. Constructing the financial literacy index using factor analysis

We constructed the *Literacy Index* using a factor analysis of six components of the answers to the three questions regarding the respondents' financial sophistication. Specifically, we constructed a dummy variable (*Quiz_Correct*) which is equal to 1 if the respondent gave the correct answer to the question and 0 if otherwise. In addition, if a respondent provided the "do not know" answer, then the dummy variable (*Quiz_DK*) is equal to 1 and 0 if otherwise.

For the factor analysis, one component has eigenvalues above 1, suggesting that the study should use one factor. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy takes values between 0 and 1, with small values indicating that overall the variables have little in common to warrant a factor analysis, and values above 0.5 are satisfactory for a factor analysis. The higher the KMO index, the more efficient the factorization. We observe that all the KMO values in our table are above 0.6, which satisfies the minimum requirement for sample adequacy (0.5).

Table A2
Constructing a financial literacy index using factor analysis.

Variables	Loading	KMO test	*Eigenvalue*	*Proportion*	*Cumulative*
Quiz_Interest_DK	0.5781	0.7417	2.7624	0.6660	0.6660
Quiz_Interest_Correct	0.8117	0.7075	0.9062	0.2185	0.8844
Quiz_Inflation_DK	0.3618	0.7462	0.3543	0.0854	0.9698
Quiz_Inflation_Correct	0.7324	0.7432	0.1250	0.0301	1.000
Quiz_Risk_DK	0.7333	0.6371	0.0002	0.0001	1.000
Quiz_Risk_Correct	0.7513	0.6428	0.000	0.000	1.000
Aggregate		0.6914			

Appendix B. Definitions of all the variables

Variable name	Definition
Ln(Wealth)	Natural logarithm of total household wealth: Household total wealth includes financial and non-financial assets. The former are the total value of stocks, bonds, funds, financial products, derivatives, foreign exchange assets, and gold owned by households. The latter are the total value of the household's commercial, agricultural and production projects, houses, land, vehicles, and other assets
Ln(Income)	Natural logarithm of total household disposable income: Total household disposable income includes household wages, production, investment, and transfer income
Age	Age of the householder
Age^2	Square of the age of the householder divided by 100
Male	Gender of the householder (one for male, zero for female)
Single_Female	Dummy variable equal to 1 if the householder is a single woman and 0 if otherwise
Married	Marital status of the householder (1 for married/cohabiting, 0 if otherwise)
Education	Years of education of the householder
Size_Household	Number of household members
Unhealth_Ratio	Ratio of the number of unhealthy members to the household size
Employed	Dummy variable equal to 1 if the householder is employed and 0 if otherwise
Homeowner	Dummy variable equal to 1 if the household owns a house (the household head is a homeowner) and 0 if otherwise
Entrepreneurship	Dummy variable equal to 1 if the household has its own business and 0 if otherwise
Party	Dummy variable equal to 1 if the householder is a communist party member and 0 if otherwise
Ability_High1	Dummy variable equal to 1 if the respondent did not rely much on interpretation by the interviewer when they answered the questions in the survey and 0 if otherwise
Ability_High2	Dummy variable equal to 1 if the respondent was able to understand the questions in the survey and 0 if otherwise
Watch_Fin_Online	Dummy variable equal to 1 if the respondent watches finance/business news online and 0 if otherwise
Trust	Dummy variable equal to 1 if the respondent trusts strangers and 0 if otherwise
Risk_Averse	Dummy variable equal to 1 if the respondent is risk-averse and 0 if otherwise
No_Branches	Number of bank branches in the community
Broadband_Access	Percentage of households that have broadband access in the city
Rural	Dummy variable equal to 1 if the household resides in a rural area and 0 if otherwise
Regions	Coastal regions: Liaoning, Tianjin, Beijing, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan Central regions: Heilongjiang, Jilin, Shanxi, Henan, Anhui, Hubei, Jiangxi, Hunan Western regions: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet Autonomous Region, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang
Ln(GRP_PC)	Logarithm of the city-level per capita gross regional product (GRP)

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